CALIFORNIA DIVISION OF MINES AND GEOLOGY

Supplement # 3 to

Fault Evaluation Report FER-13

April 18, 1978

Name of fault: Ventura fault.

Significant Conclusions and Recommendations

1. The Ventura fault is a well-defined Holocene feature. The surface expression of the fault is characteristically a faulted monoclinal fold. Data gathered by Geotechnical Consultants (1977), Smith (1977a), and Yerkes and Sarna-Wojcicki (written communication, 1977) serve to reinforce the original recommendation to zone the Ventura fault.

2. None of the reports submitted disproves the existence of the Ventura fault either on or near their respective sites. Indeed, both the Geotechnical Consultants (1977) report and the Cilweck (1975) report are strong evidence that the fault as mapped by Sarna-Wojcicki, et al. (1976) is indeed located where they depict it.

Therefore, it is recommended that the official Special Studies Zones maps of the Ventura and Saticoy quadrangles be issued without modification of the zone boundaries. This should be done as soon as feasible.

Review of New Data

This FER Supplement is a summary review of five reports submitted to CDMG by the City of Ventura. Two of these reports were financed by the City (Geotechnical Consultants, 1977 and 1978). These reports are indexed on figures 1 and 2.

Buena Engineers, Inc. (1977) Report

The Buena Engineers (1977) report was performed after it was noted in the EIR that a "potentially active earthquake fault" lay beneath the site. The site lies about 1100 feet north of the proposed SSZ, approximately on the trace of an inferred fault of Weber, et al. (1975; see plate 2 of original FER). The ~~trend~~ trench logs lack detail (the surface and contacts were obviously drawn with a ruler or triangle), but apparently no faults were noted in late Pleistocene terrace deposits. If a fault exists near here it is most likely south of the site at the base of the slope. Trench C-C' did show a tremendous thickening of the upper unit at the southern end -- no explanation was given for this thickening.

Gorian and Associates (1977) Report

The Gorian and Associates (1977) report covers a site within the proposed SSZ, just south of the Geotechnical Consultants, Inc. (1977) report on the reservoir site. The 10-foot deep trench that was dug was 200 feet long and stopped about 45 feet south of the northern property line. The trench logs, which are fairly detailed, show unfaulted, horizontal fan deposits. A carbon sample was collected from approximately four feet four inches below the surface and was dated by Teledyne at 450± 220 y.b.p. (C.A. Swift, p.c., 3/2/78).

Buena Engineers, Inc. (1975) Report

This report covers one of the parcels also covered by Geotechnical Consultants, Inc. (1978). Buena Engineers uses little more than hearsay and some boring logs (to 15 deep) to rather ineffectually dismiss the entire Ventura fault as imaginary. No cross section was

included in the report, but Buena Engineers concluded no fault existed on the site.

Geotechnical Consultants, Inc. (1977) Report on Reservoir Site

This report raises two basic questions (p. 16): 1) does the Pitas Point fault connect with the Ventura fault, and, 2) do the recorded epicenters indicate left-oblique reverse slip or right-oblique reverse slip? The authors also suggest (p. 16) that the fractures noted in the trench might be caused by earthquakes on other nearby faults. They also (p. 16) state that Holocene activity along "a Ventura fault" at depth or near the surface cannot be proven. Finally, they state (p. 14) that deep drill holes did not intersect a major fault nor did it "indicate that the approximttely forty feet of topographic escarpment on the site is related to tectonic slip along a fault at depth."

Whether the Pitas Point fault connects with the Ventura fault may have some bearing on the size of the design earthquake, but time does not permit us to track down all the pertinent data and reach an independent conclusion on the connection.* It is more important to analyze and explain the features that are known to exist rather than to dismiss these features altogether based on such questions as this. I do note that Geotech presented no substantive data to support their statement regarding this hypothesis.

Again, both Geotechnical Consultants (1977) and Sarna-Wojcicki, et al. (1976) at least agree that reverse movement is indicated by local epicenters. However, it should be noted that Geotech cites Hilesman, et al. (1973) of Cal Tech while Sarna-Wojcicki, et al. cite Lee and Vedder (1973) of U.S.G.S. The U.S.G.S. has a much ~~looser~~ denser and more closely

* According to Yerkes and Sarna-Wojcicki (written communication, 1978) the Green reference used by Geotech, indirectly, as evidence for a south-dipping Pitas Point fault is misrepresented (by Geotech) ~~of Green~~ Green (1976) clearly states (p. 509-510) that the Pitas Point fault ~~dips~~ is a northward ~~dipping~~ dipping thrust or reverse fault.

located network of seismographs (figure 3). Lee and Vedder noted significant differences between the locations of the same 25 earthquakes as determined by the two teams (figure 4). It is logical to consider the U.S.G.S. locations (and their derivation of the senses of displacement) as the better data.

As for the suggestion that earthquakes located on other nearby faults could have caused the fracturing, it is difficult ~~for me~~ to conceive of a rather linear (for several miles) 40-foot high escarpment being formed during the last 15,000 years by other than the release of local (on-site) stresses (faulting and folding). I also note that the FER's completed on the faults suggested as sources for such earthquakes indicate that there is no known, conclusive evidence for Holocene or, in some cases, late Pleistocene activity on these faults (Bortugno, 1977; Hart, 1978; Smith, 1977b, 1977c, 1977d, 1977d, 1977f) except possibly along the Red Mountain fault (Smith, 1977e).

Perhaps the weakest statement in the report was that regarding the lack of conclusive evidence for Holocene fault activity (Geotechnical Consultants, p. 16). It is apparently true that Geotech did not intersect a major fault plane in the core holes. However, as Geotech (p. 15, after Collins, 1973, p. 5) points out, major displacements can decrease dramatically within relatively short, vertical distances. Geotech did find faults in a monocline near the surface (although they didn't recognize them as "faults"). They did find some minor faults (again, not their term) in Drill Hole 3 at a depth of up to 32 feet. It should also be noted that if the fault that has six inches of displacement (station 315 on their log) dipped more steeply than about 58° N (apparent dip in plane of cross-section is approximately equal to the true dip) it would not be intersected by Drill Hole 3. Since Geotech recorded this fault as dipping

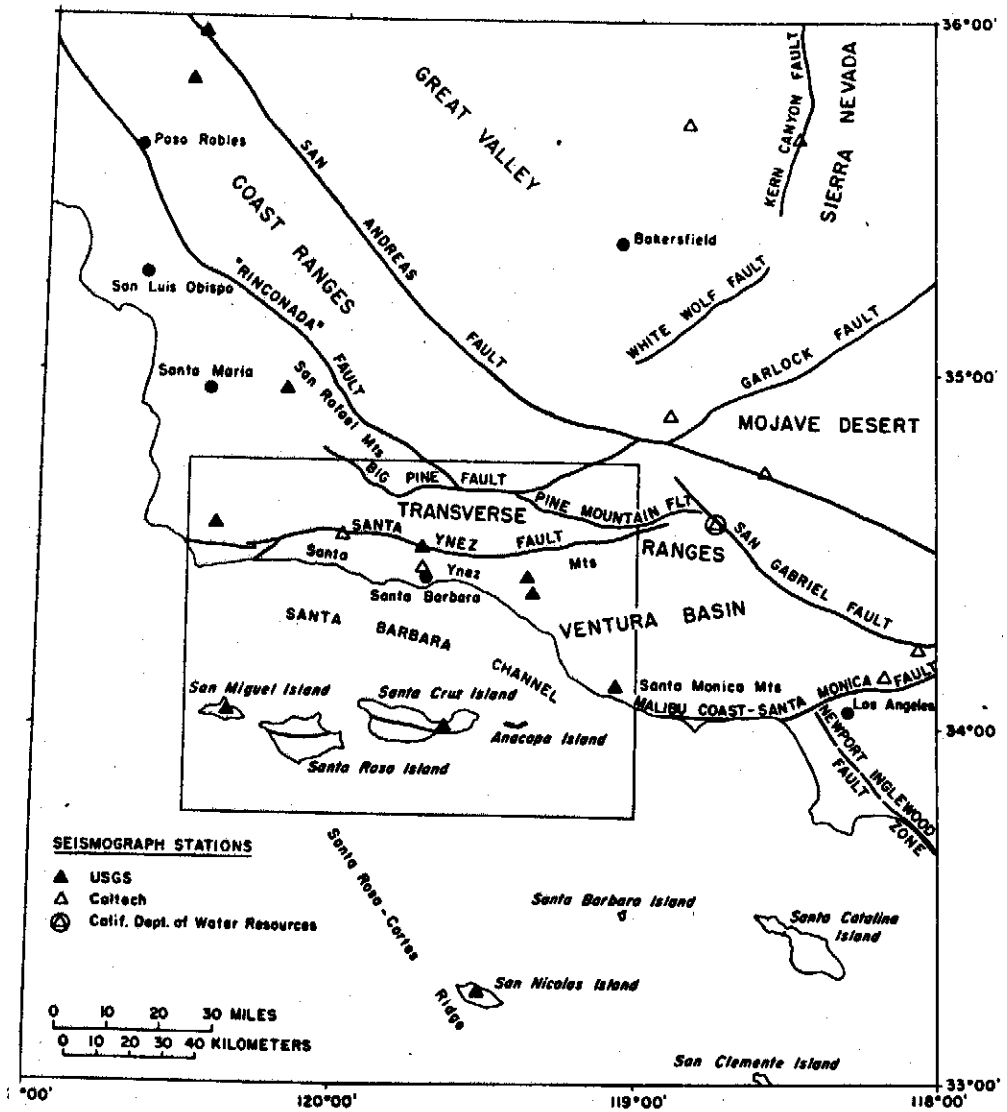

FIG. 3. Index map showing location of seismograph stations, selected major faults, and geomorphic provinces with respect to the Santa Barbara Channel region (boxed area). (From ~~Vedder [1971]~~, Lee and Vedder, 1973, p. 1758.

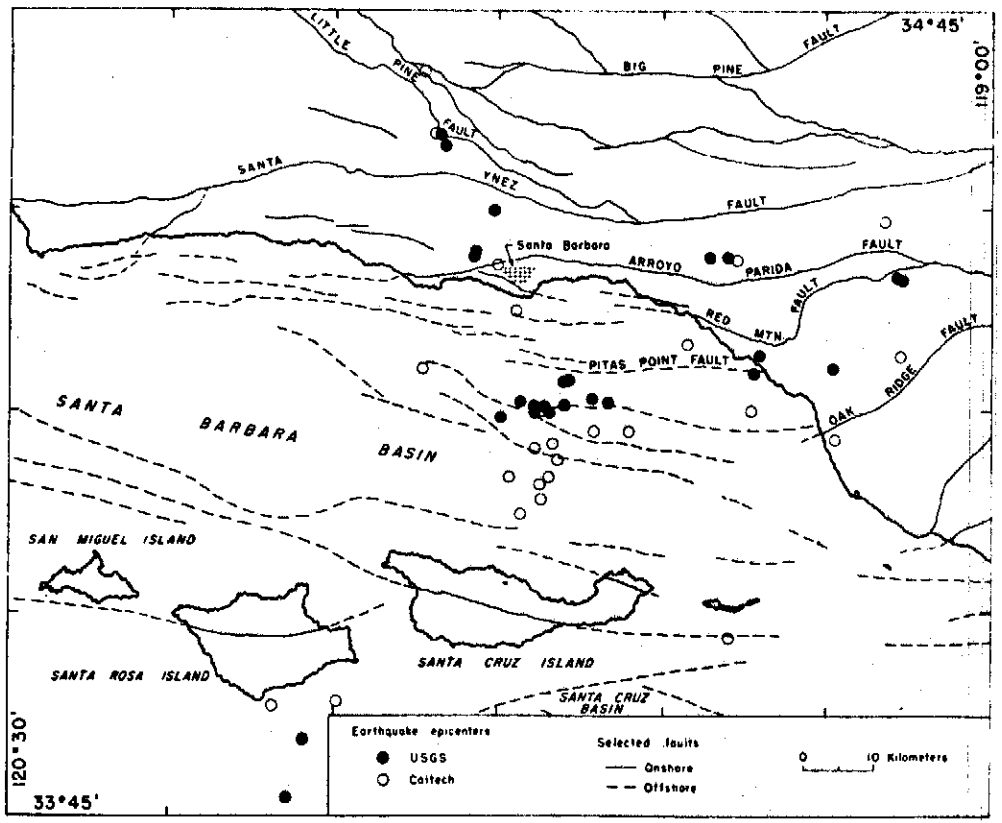

FIG. 4. Comparison of epicenters determined by U.S. Geological Survey (dots), and epicenters determined by Caltech (circles) for the same 25 earthquakes in 1970–71. (From Lee & Vedder, 1973, p. 1769).

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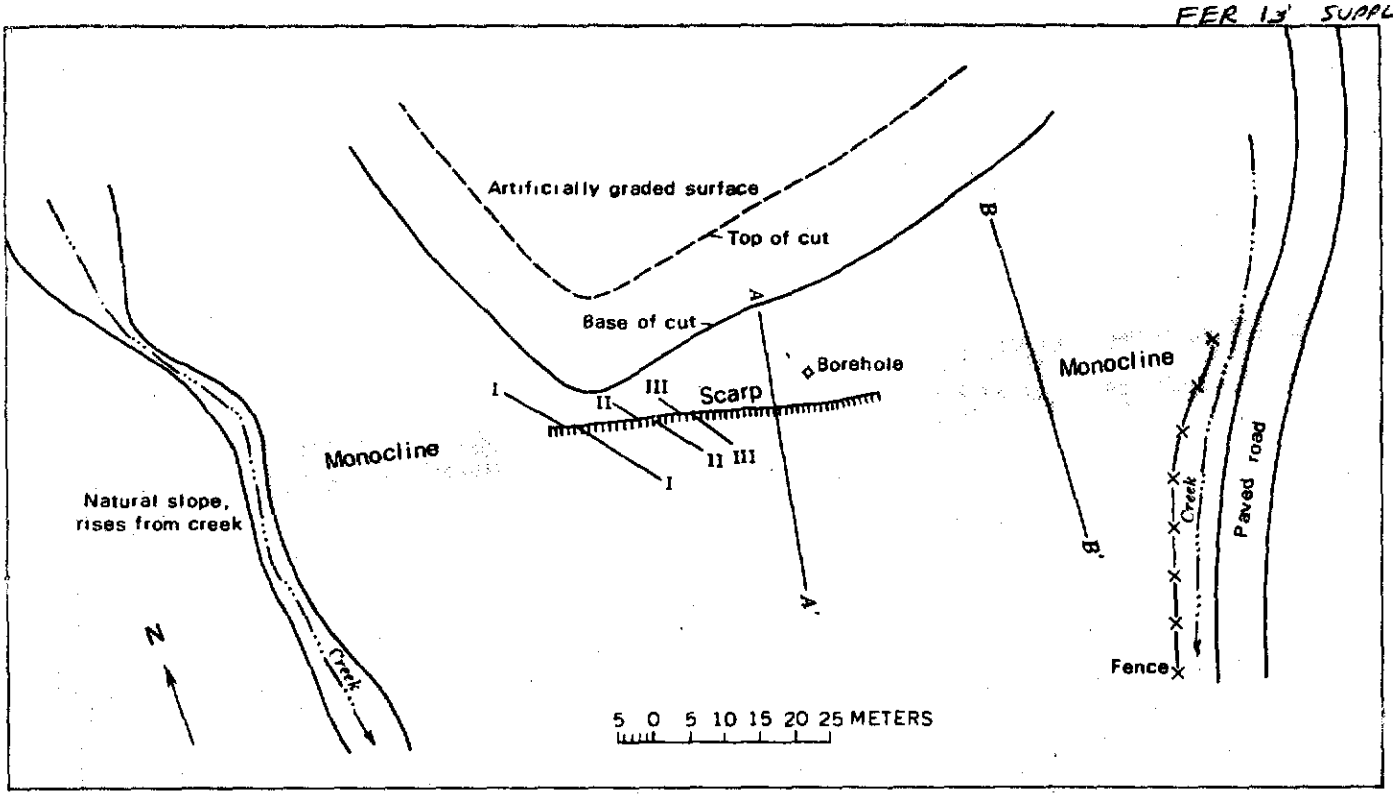
65° N, they should not have expected to intersect the fault. Indeed, it would appear that all the faults logged for a distance of 60 feet south of this fault (where the overwhelming majority of the faults were located) would not have been intersected by any of the drill holes. As for the Holocene age of the fault, a ^{14}C date of 15,200± 350 years was obtained from approximately 8 1/2 feet below the surface. Geotech's log of the west wall specifically noted that two of the faults (stations 315 and 325) did not offset a slightly older horizon. Another fault (station 332) was depicted as not offsetting a younger sand unit. However, Yerkes and Sarna-Wojckcki (written communication, 1977) and Smith (1977) both documented displacements well above the sample, on the east wall, apparently on the same faults and horizons that were labeled "no offset" by Geotech. Thus, we have definite proof of displacement after 15,200 ± 350 y.b.p.

Geotechnical Consultants (1977) also chose to ignore the fact that the escarpment also crosses the surface of Harmon fan immediately east of the reservoir site. Sarna-Wojcicki, et al. (1976) concluded that Harmon fan is most probably Holocene, based on a 6000 y.b.p. date of some gopher bones. Thus there is little doubt that faulting has taken place during the Holocene.

One could argue whether the Ventura fault is actually a fault or a monocline. At the surface it is a monocline. More precisely, it is a faulted monocline, and has apparently been uplifted and faulted during the Holocene. During the 1971 San Fernando earthquake, near Lopez Creek a case was noted where a fault "died out" at either end in a monoclinal fold (Bonilla, et al., 1971; see figure 5). The implications are



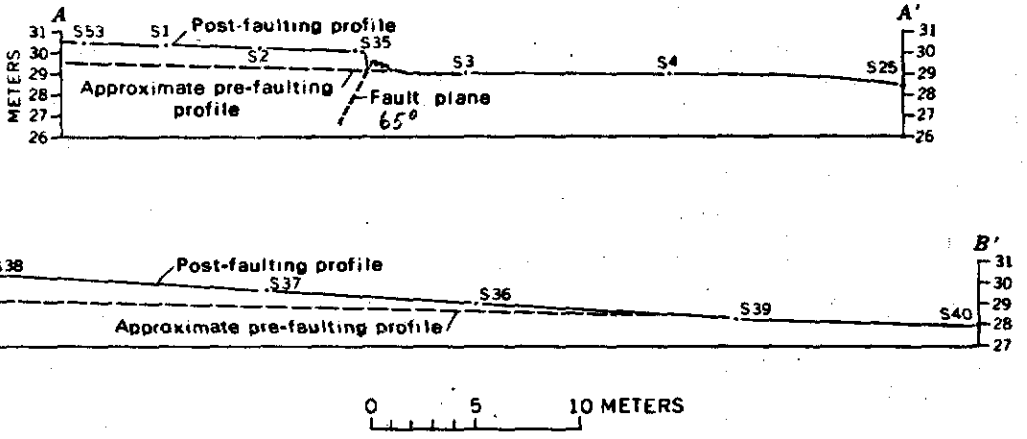


FIGURE 5.—Plan and profiles of trace of fault 0.9 km north of mouth of Lopez Canyon, based on planetable mapping. For location see figure 2. Elevations on profiles referred to local assumed datum. Numbers preceded by S are field survey stations. (from Bonilla, et al., 1971, p. 69).

obvious. However, the State Geologist, rather than zoning on the basis of the presence of an "active monocline" should definitely zone the active faults that occur on the monoclinal fold. Geotechnical Consultants (1977, p. 17), although refraining from calling these faults "faults" (they called them "soil fractures" and stated that these fractures exhibited offsets -- by dictionary definition what they describe are faults) at least recognized that critical structures should not be placed over them.

Geotechnical Consultants, Inc. (1978) Report on Redevelopment Site

The Geotechnical Consultants, Inc. (1978) report on the redevelopment site located at the western end of the proposed SSZ relies mostly on drill hole data and a series of short trenches (the site was too steep for a single, continuous trench). All of the drill holes and bore holes (except DH3 which was only about 10 feet deep) were located ~~below~~ south of the escarpment.

Geotechnical Consultants (1978) projected their trench logs and drill hole data into common cross-sections. It is apparent that much of the "data" shown on the sections are extrapolated, and may not be verified in the actual logs of the bore holes. For example, section B-B' (their plate 3) has an "Information Gap" even larger than that shown on the cross-section. This "Information Gap" lies very near the base of the slope, precisely where one might expect to find a fault. The same unit apparently exists on either side of the "Information Gap", but nothing precludes a fault in this locality since unit G upslope may be stratigraphically lower than unit G downslope.

Also, it is disturbing to examine the cross-sections and the drill hole logs simultaneously. If one does so, it is apparent that

some of the contacts indicated on the cross-section were not based on the data recorded in the drill hole logs. For example, in DH4 the upper contact of sand unit C'-2a on the cross-section shows a dip of 10° , but this isn't recorded in the log. The contact between C'-2u and the E unit is shown as a solid line in the cross-section but queried in the log -- in fact the description of the units didn't note any lithologic changes at this depth. According to p. 10, a radiocarbon date of 23,000±920 y.b.p. was taken from unit E, but the log and cross-section used together show the sample as taken from unit F. This is typical of the data for each of the logs. It is impossible to correlate with any degree of certainty from drill hole 4 to drill hole 6. The unit descriptions do not match.

Both CDMG staff and USGS staff noted that the dip described in the log of DH2 at 20' depth is 20° . Geotechnical Consultants (1978) cross-section A-A' shows a dip of 32° to 35° instead of the 20° logged. (Geotech did, however, note that the 20° attitude was questionable). Also, the paleosol (E) noted in the trench and DH2 was not found in DH4. ~~Replotting~~ Considering only the raw data used in section A-A', one could very easily have an offset of several feet between DH2 and DH4. Yerkes and Sarna-Wojcicki (written communication, 1978) point out that DH4 is the only drill hole in which Geotech found strata dipping more than 30°. They also state that most other recorded subsurface dips in the downtown area are less than 10°. Therefore, a significant anomaly may exist near DH4.

Geotechnical Consultants (1978) apparently expects one to accept, via section B-B', that unit E or F (depending on whether one believes the text or the logs and cross-section) was deposited 23,000 years ago, was

uplifted to a 32° to 35° tilt, was eroded to horizontal, was the site of deposition of stream gravels, was eroded extensively, and again was the site of deposition. However, Yerkes and Sarna-Wojcicki (written communication, 1978) point out that there are marine terraces, 100,000 years old, upslope that are tilted 15° or less and that these terraces unconformably overly the 23,000 year old units according to Geotech's cross-section. It is difficult to reconcile the two attitudes and the stratigraphic anomaly without an intervening structure. Yerkes and Sarna-Wojcicki go on to calculate a rate of uplift based on the 23,000 year date of 4 to 5 m per 1,000 years.

Finally, Geotechnical Consultants (1978, p. 16) concludes that the younger units are tilted less than the older units. They state, "Such conditions are indicative of dimininshing tectonic effects within the last 23,000 years." However, they present no data on the rate of sedimentation and thus, have no basis for this conclusion. Instead, since progressively younger units show progressively less tilt, it is suggested that the site has been subjected to continued tectonic stresses during the past 23,000 years. (Using a hypothetical example, assume an area has been tilted 1° per 1,000 years. Sediments 1,000 years old would be tilted 1°, sediments 10,000 years old would be tilted 10°, and so on.)

Thus, serious questions have been raised regarding the ability of anyone proving that a fault does not exist on the site using data in this report. One cannot preclude the western end of the Ventura fault from crossing the site or even crossing just north of the site (although this is less likely).

Additional Comment

It is apparent that Geotechnical Consultants (1977) has purposely avoided using the term "fault" for any of the faults noted in the exploratory trench -- instead, they used the term "fractures" and note they "exhibit offsets." By any dictionary consulted (the AGI Glossary, for example) such "fractures ... exhibit (ing) offsets" are faults. It is difficult to believe that any reputable firm could conduct an investigation specifically to prove or disprove the existence of an active fault, and then upon discovering a fault avoid using the term "fault".

The State, under the Alquist-Priolo Special Studies Zones Act, does not recognize differences between faults. All faults are treated equally whether they be primary or secondary faults, caused by tectonic processes or subsidence, creeping or earthquake related. Similarly, the magnitude of displacement (6 inches for one fault on the reservoir site (Geotechnical Consultants, 1977) is as large as or larger than that created during the 1975 Oroville earthquake. In the latter case, the causative fault was zoned in 1977. Therefore, zoning of the Ventura fault is the logical course of action.

State law prohibits the construction of structures for human occupancy over the trace of an active fault. This does not mean that the fault has to cut Holocene deposits on every site.

While State law is directed at active faults, it is not necessarily directed at monoclinal folds. The magnitude of displacement on any single fault in the zone appears to be six inches or less; however, the monoclinal escarpment is almost 40 feet high in places. Since it is reasonable to assume that both the monoclinal folding and the secondary

faulting were created simultaneously by the same forces, it is also reasonable to expect future folding to occur, perhaps of a much longer magnitude than future fault displacement. Such folding and faulting could be quite damaging to any structure placed across or on the escarpment. Thus, it is recommended that the escarpment be avoided, at least for all high-risk structures. It is recognized that local government may accept or reject such a recommendation and its consequences.

Recommendations

In light of the information summarized in this supplement and earlier reports on the Ventura fault (Smith, 1977a), and the present project guidelines, zoning of the Ventura fault is recommended. No change in the boundaries of the proposed Special Studies Zone is recommended. The zone maps of the Ventura and Saticoy quadrangles is should be issued as soon as feasible.

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Richard M. Stewart August 24, 1978

Earliest references to the Ventura fault.

Ogle and Hacker (1969) show a north-dipping reverse fault along the south margin of the Ventura Avenue anticline on a north-south cross-section drawn east of the City of Ventura. The presence of the fault apparently was inferred from repetition of faunal horizons at about the 1500 m level in a corehole (Tidewater 5). They show the fault dipping 60° to the north, with the north block thrust up. Ogle and Hacker do not show the fault extending to the surface; its projection would intersect the surface somewhat further north than the Ventura fault as we now map it; they refer to the fault as the Pitas Point fault.

Quick (1973) also infers a north-dipping reverse fault along the south margin of the Ventura Avenue anticline. He cites uplifted marine terraces, the subsurface data of Ogle and Hacker (1969), an inferred groundwater barrier near the mouth of the Ventura River, and possible oil seeps along the base of the Ventura Hills near the intersection of Foothill and Wells Roads. The position of this fault, which Quick calls the Ventura Foothills fault, coincides with the Ventura fault, as it is now mapped, only at the western end along the base of the hills east of the Ventura River.

Weber and others (1973) saw the Ventura fault as an air photo lineament on older photography and mapped it as such. Cilweck (1975) studied a portion of the Ventura fault in detail as part of an investigation of the Ventura County Hospital grounds. Weber and others (1975) mapped the fault, and Sarna and others (1976) made a study specifically directed to this fault.

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